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Title: Kilowatt Reactor Using Stirling TechnlogY (KRUSTY) Component Critical Measurements

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Kilowatt Reactor Using Stirling TechnologY (KRUSTY) Component Critical Measurements

By

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Sixty measurements were conducted in support of the KRUSTY component critical measurements. The purpose of these measurements was to provide high quality critical and reactor physics benchmarks that can be used to test neutron cross-sections data used in steady-state and dynamic computer models.

Kilowatt Reactor Using Stirling Technology (KRUSTY) Component Critical Measurements

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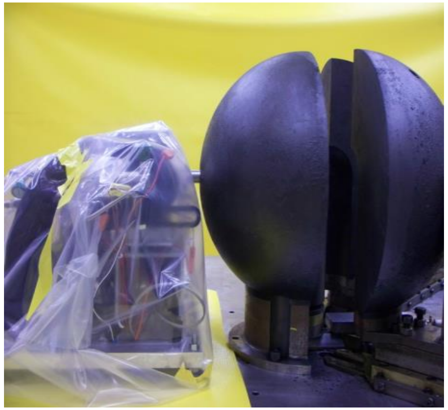
2 October 2020

Outline

- Background
- Objectives of the KRUSTY experiment
  - KRUSTY test phases
- Comparison of measured data vs Simulations
  - Results of warm criticals
- Conclusions

Background



- 2012 NCERC and NASA conducted a small scale demonstration experiment called DUFF (Demonstration Using Flat-Top Fissions)
- 2014 Planning of the next demonstration experiment is examined
- 2015 Kilopower (KRUSTY) project gets started
- 2017 KRUSTY experiment begins (November)

Objectives

- The main objective of the KRUSTY experiment is to evaluate the operational performance of a compact reactor that closely resembles the flight unit NASA will use for deep exploration missions
- Test the dynamic behavior (transients) of the reactor
- Test the integrity of the fuel

KRUSTY test phases

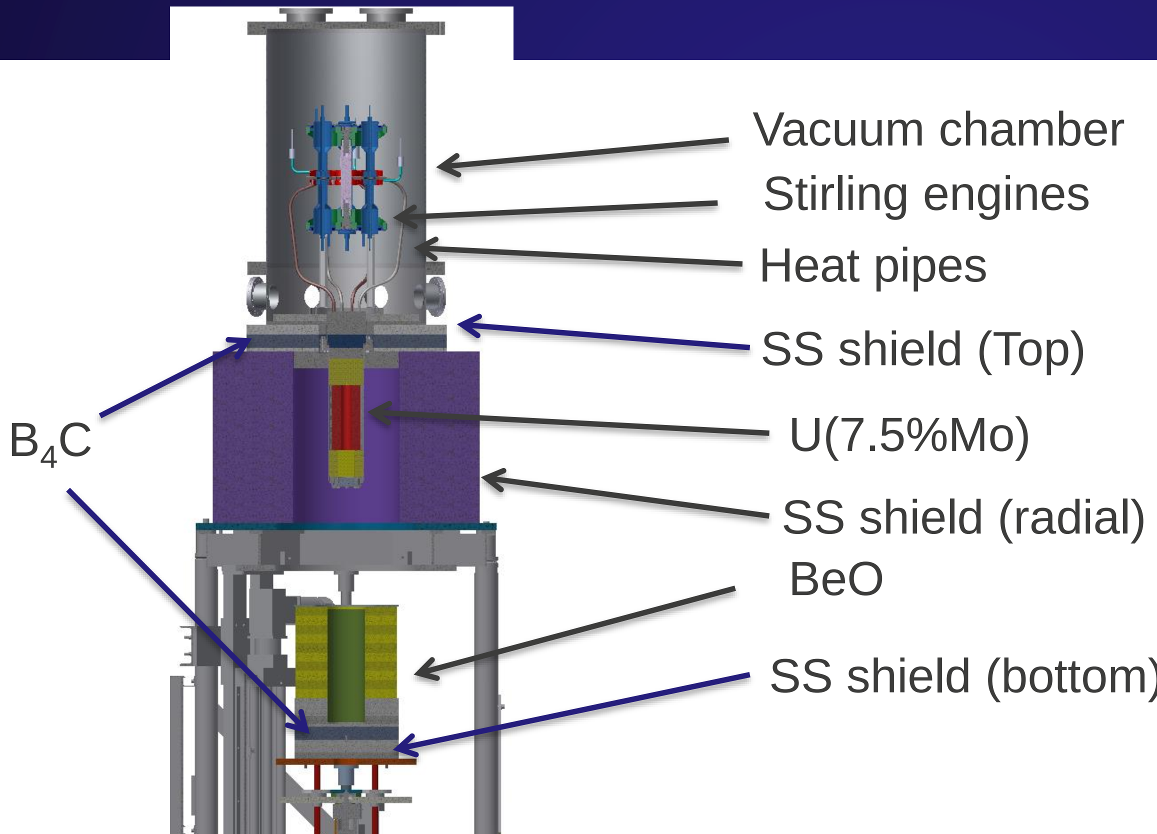
Phase 1: Component Critical Measurements
- Critical configuration is determined
- BeO reflector worth measured
- B_4C control rod worth measurements
- Room temperature

Phase 2: Cold Critical Measurements
- Heat pipes installed
- Stirling engines installed
- Above items in a vacuum chamber
- Critical configuration found
- B_4C control rod worth measurements
- Room temperature

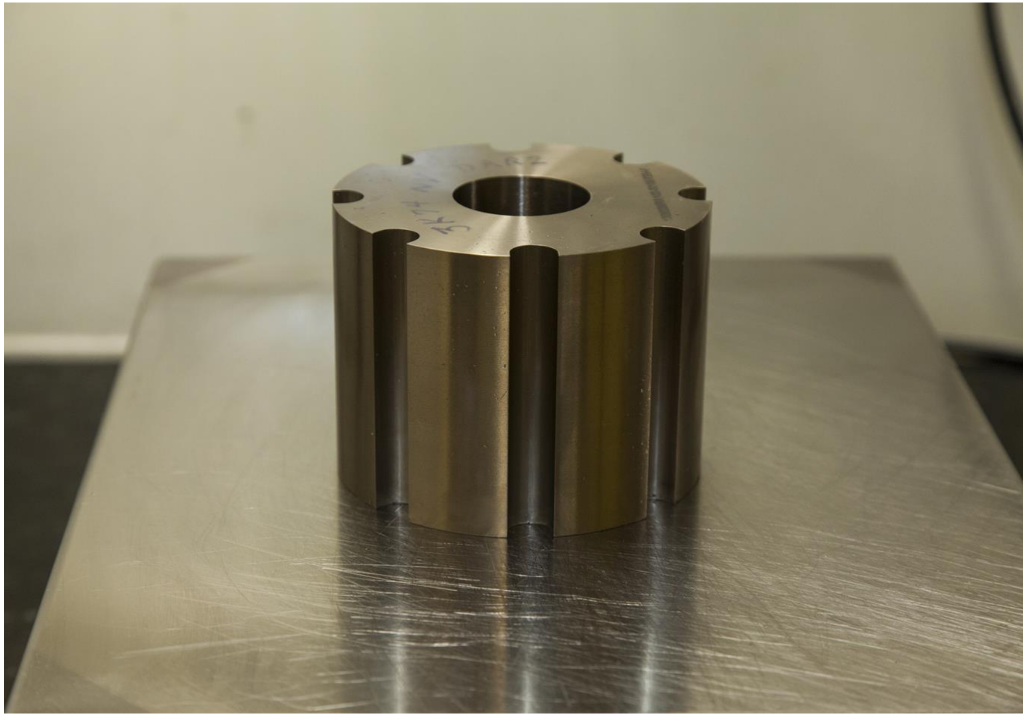
Phase 3: Warm criticals
- 15 cent free run,
- 30 cent run,
- 60 cent run
- Moderate temperature rise (<450°C)

Phase 4: High Temperature Operations
- Mission power profile is executed
- Significant temperature rise (800°C)

KRUSTY Experiment

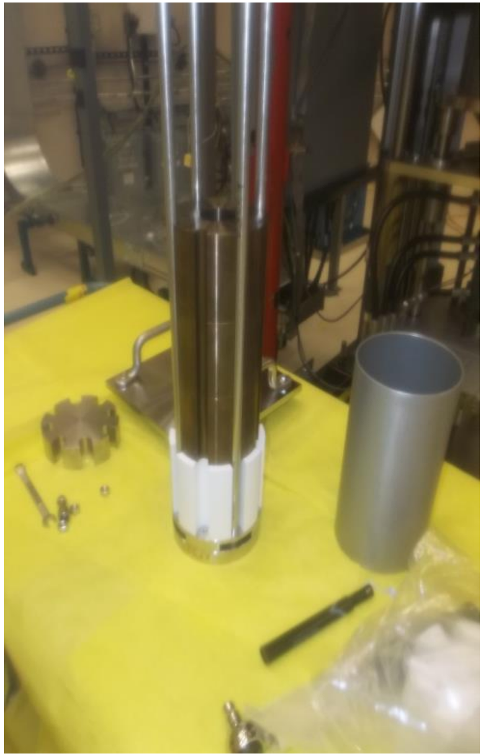


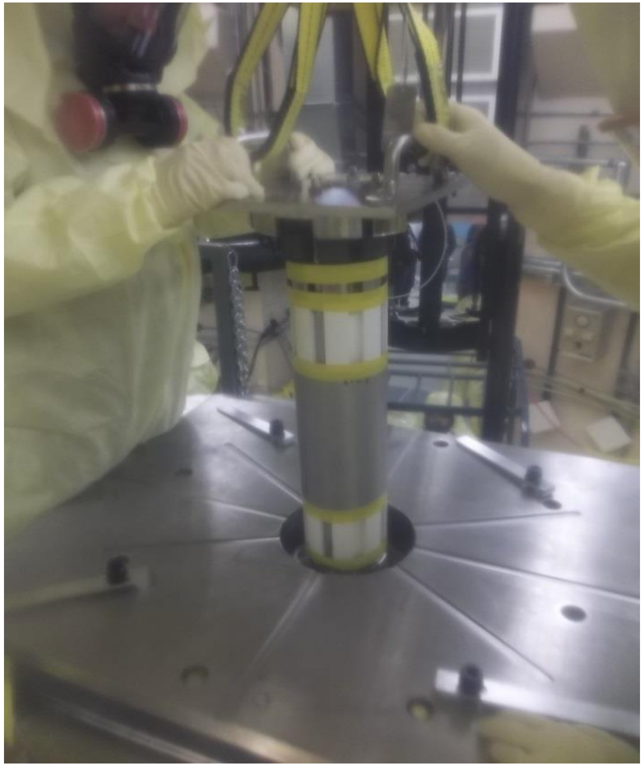
Core for the KRUSTY Experiment



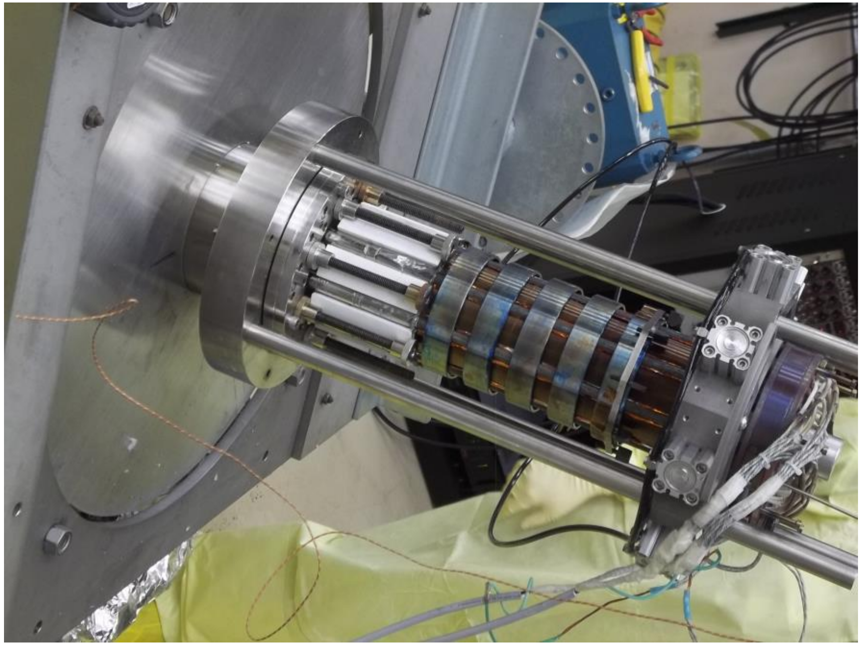
- **Weight ~ 11 kg**
- **Density** ~ 17.4 g/cc
- **Uranium alloy (~7.5 wt% Mo)**
- **The uranium is isotopically enriched to ~ 93 wt% ^{235}U**

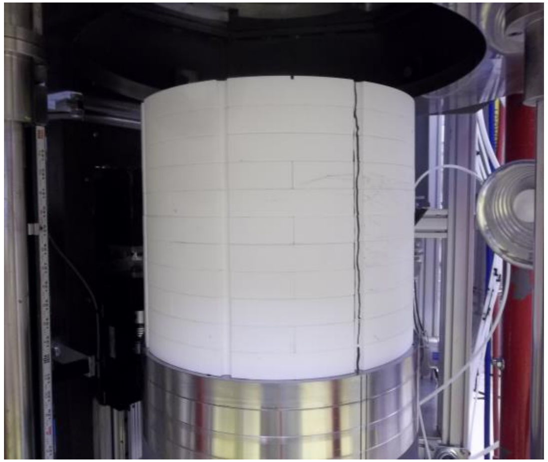
Phase 1: Component Criticals





Phase 2: Cold Criticals





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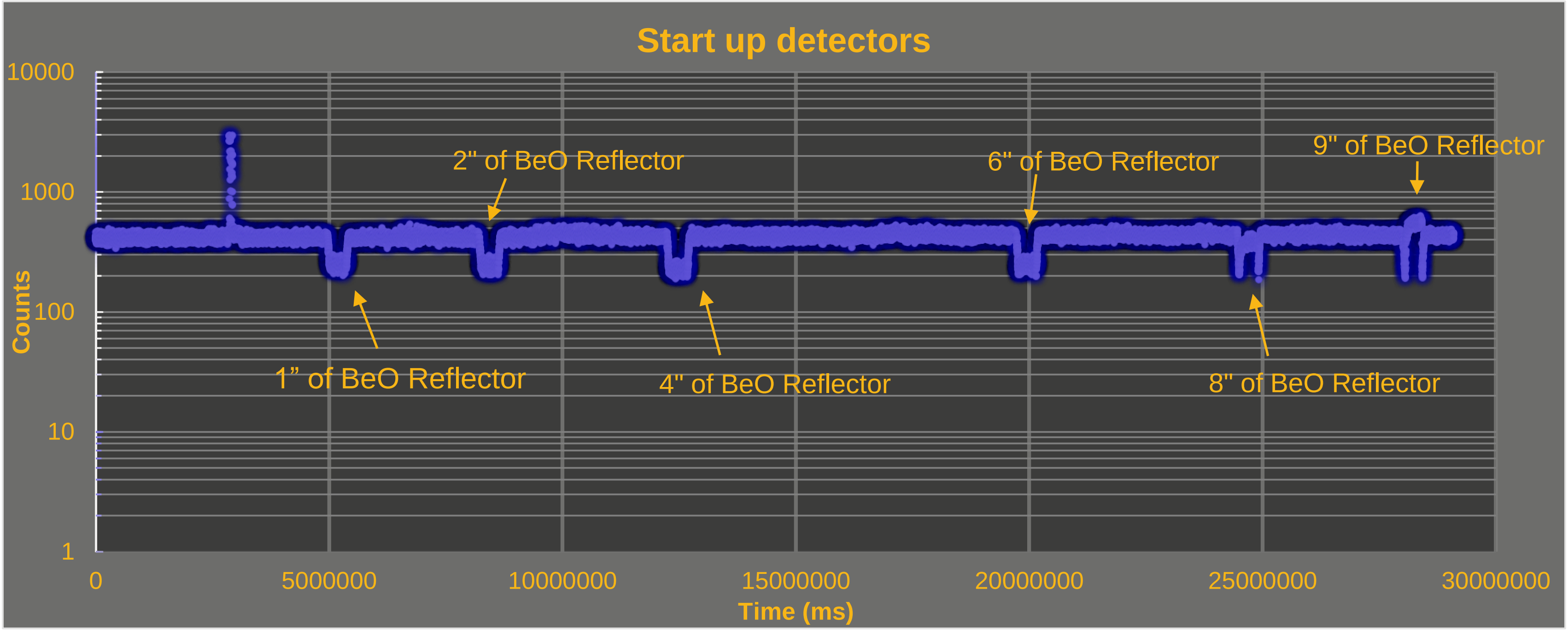
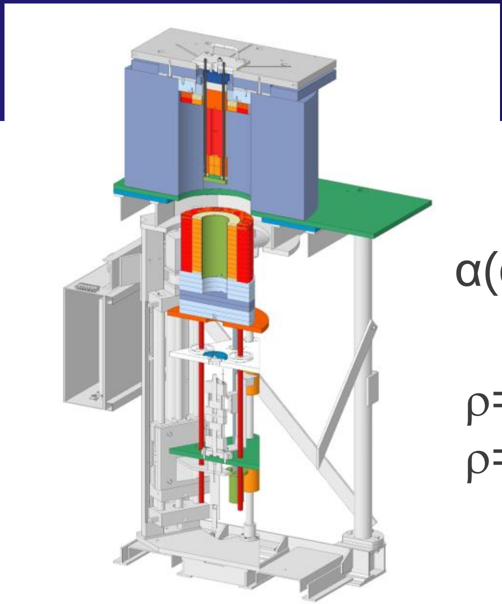
Multiplication vs Reflector Height



1/M vs Reflector Height

	C1	C2	C3	C4	total	1/M
1	668	615	545	577	2405	1
2	627	630	603	539	2399	1.002501
4	599	594	555	478	2226	1.080413
6	648	622	579	573	2422	0.992981
8	1037	973	878	885	3773	0.637424
9	1461	1382	1303	1273	5419	0.443809



α(cents/°C) = 0.3

ρ= 800*0.3
ρ=240 cents

BeO (*cents/mil*) = (*51.7* -8.5)/(11375 – 11250)
= 0.346 cents/mil

BeO Needed = 240/0.346 = 693 mils

Results(Component Criticals)

Sequential Operations Configuration	BeO Height (in)	Shim BeO (in)	B_4C Height (in)	Source Holder	Source Holder installed	Reactivity Measured (cents)	Reactivity Calculated (cents)
Baseline initial critical	11.250	0	0	Al	x	9.50	10.6
Unload and reload 4" of BeO	11.250	0	0	Al	x	6.90	10.6
No change	11.250	0	0	Al	x	6.90	10.6
Only top source plug removed	11.250	0	0	Al	x	6.80	10.6
Only bottom source plug removed	11.250	0	0	Al	x	7.00	10.6
Both source plugs removed	11.250	0	0	Al	x	6.90	10.6
Plug replaced (baseline)	11.250	0	0	Al	x	8.50	10.6
Add 1/8" BeO	11.375	0	0	Al	x	51.60	52.4
No change	11.375	0	0	Al	x	50.00	52.4
Remove 1/8" BeO (baseline)	11.250	0	0	Al	x	9.20	10.6
Remove source and holder	11.250	0	0			2.30	1.6
No Change	11.250	0	0			2.30	1.6
Add 1/8" BeO	11.375	0	0			45.20	43.4
Add Al source holder	11.375	0	0	Al		46.80	46.2
No change	11.375	0	0	Al		48.20	46.2
Remove 1/8" BeO	11.250	0	0	Al	x	5.01	4.4

Control rod worth measurement (Phase 2: cold criticals)